DOCUMENT RESUME

ED 349 180 SE 053 186

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TITLE Preparing Elementary Teachers to Teach Mathematics: A Problem-solving Approach. Final Report. Volume I: Overview.
INSTITUTION Indiana Univ., Bloomington. Mathematics Education Development Center.
SPONS AGENCY National Science Foundation, Washington, D.C.
PUB DATE Jun 92
CONTRACT TEI-8751478
NOTE 32p.; For volumes II-V, see SE 053 187-190.
PUB TYPE Reports - Descriptive (141)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Elementary Education; *Elementary School Mathematics; Elementary School Teachers; Higher Education; Instructional Materials; Lesson Plans; Material Development; Mathematics Education; *Mathematics Instruction; *Mathematics Teachers; Methods Courses; *Preservice Teacher Education; *Problem Solving; Resource Materials; *Teacher Education Curriculum; Teaching Methods; Videotape Recordings
IDENTIFIERS Subject Content Knowledge

ABSTRACT

The "Preparing Elementary Teachers to Teach Mathematics (PETTM) Project" (1988-1991) was a cooperative university/school effort to improve the teaching of mathematics by elementary teachers with primary focus on improving the university training of preservice teachers (PSTs) in mathematics. The goals of the PETTM Project included: (1) improving teacher preparation through a problem-solving focus in university mathematics courses; (2) developing a program to prepare students who wish to make mathematics their field of concentration; (3) developing jointly a plan for intensive early field experiences for all prospective teachers in local school districts; and (4) establishing support mechanisms to help practicing teachers: (1) broaden their views of the nature of mathematics, and (2) utilize innovative teaching techniques for improving their pupils' mathematical thinking skills and use of problem-solving strategies. The PETTM Project was comprised of four components: the "Content Component," the "Methods Component," the "School Component," and the "Research and Evaluation Component." This document, volume I of the project's 5-volume final report, provides an overview of the entire project. An introductory section includes the background and rationale for the project and a description of the four components of the project. Two sections provide lists of publications and presentations related to the PETTM Project. The final section describes educational products resulting from the project in three categories: (1) products related to the content component of the project; (2) products related to the methods component of the project; and (3) products related to the school component of the project. (MDH)

ED349180

Preparing Elementary Teachers to Teach Mathematics:

A Problem-solving Approach

Final Report

National Science Foundation Grant TEI 8751478

Volume I: Overview

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PREPARING ELEMENTARY TEACHERS TO TEACH MATHEMATICS: A PROBLEM-SOLVING APPROACH

OVERVIEW OF THE ENTIRE PROJECT

The *Preparing Elementary Teachers to Teach Mathematics Project* (1988-1991) was a cooperative university/school effort to improve the teaching of mathematics by elementary teachers. The primary focus of the project was the improvement of the university training of preservice teachers (PSTs) in mathematics. In the late-1980s, Indiana University had been involved in making plans to institutionalize a new four-year program for elementary education majors in 1989. Two elements of this new program were directly related to the work of the *Preparing Elementary Teachers to Teach Mathematics Project* (*PETTM*). These two elements are:

1. each elementary education major must complete an 18-24 semester credit hour concentration in an approved area (one of those areas being mathematics); and
2. each prospective elementary education major must take part in a three semester sequence of concentrated early field experiences working in a school prior to student teaching.

The goals of the *PETTM* Project included:

1) better preparing all elementary school teachers through a problem-solving focus in newly developed mathematics courses at the university;
2) developing a program of concentration in mathematics consisting of some existing courses and some newly developed courses and experiences to prepare students who wish to make mathematics their field of concentration;
3) developing a close working relationship with the local school district to jointly plan for intensive early field experiences for all prospective teachers;
4) establishing support mechanisms to help practicing teachers in the school district broaden their views of the nature of mathematics and to help them utilize innovative teaching techniques for improving their pupils' mathematical thinking skills and use of problem-

solving strategies. As a result, local teachers should eventually be able to serve as role models in the teaching of mathematics using a problem-solving approach for the prospective teachers who visit their classrooms.

Background and Rationale

A number of national reports published in the mid-1980s called for the improvement of education at all levels. Three reports which attracted national attention were the NCATE Redesign (Gollnick & Kunkel, 1986), the Holmes Group report (1986), and the report of the Carnegie Task Force (1986). Based on the assumption that the quality of education is directly related to quality of teachers, these reports proposed dramatic changes in the practices used in recruiting, preparing, and certifying elementary school teachers. Both the Holmes Group and the Carnegie Task Force reports called for the elimination of undergraduate programs. All of the reports proposed broader and deeper backgrounds in liberal arts. The reports also called for closer ties and working relationships between teacher preparation institutions and school districts.

An elementary education Task Force at Indiana University studied the reports and, while seeing merit in many of their recommendations, declined to join the Holmes group. Although educators at Indiana University certainly agrees with the need for graduate work in education, they also feel that such study is more profitable after some teaching experience has been acquired. Further, the Task Force believed that it is quite possible to train elementary school teachers in a well designed four-year program (cf., Mehlinger, 1986). Thus, in 1989, Indiana University instituted their new four-year elementary education program, a program which incorporated many of the recommendations common to the reports mentioned above. Faculty in Mathematics Education and in Mathematics at Indiana University saw the revision of the teacher education program as a unique opportunity to improve the mathematics preparation of elementary teachers.

Project Description

The *Preparing Elementary Teachers to Teach Mathematics Project* was comprised of four components, all of which were designed to contribute to improving mathematics instruction in elementary schools: the *Content Component*, the *Methods Component*, the *School Component*,

and the *Research and Evaluation Component.*

The *Content Component* involved revision of the university mathematics courses required of PSTs in a fashion that could be exported to other teacher training institutions. Under the new Elementary Education program, prospective elementary teachers would take two mathematics courses: a finite mathematics course (M118—already required of freshmen intending many majors) , and a newly designed mathematics course specifically for education majors (T104). Under project auspices, the former course was restructured and the latter designed completely from scratch, so that problem solving is now a central focus in both. In other words, efforts are now being made to teach university-level mathematics with the same problem-solving approach that the Project would like to see teachers use when they work with children.

The *Methods Component* of the Project had three major goals: 1) to develop well-structured field experiences for both the existing mathematics methods course and a proposed new problem-solving methods course, 2) to develop and institutionalize the new problem-solving methods course (to be required, along with additional mathematics courses, of those students who would elect mathematics as their area of concentration), and 3) to develop a computerized problem-solving data bank to be available for use not only by students enrolled in methods classes and field experiences, but also by prospective teachers in other courses and local teachers in the schools.

An important part of the training of PSTs is experience with classroom teachers and their students. The purpose of the *School Component* of the Project was for Indiana University faculty to work together with faculty from a local elementary school (Dyer/Highland Park) to provide the best possible environment for early field experiences in mathematics for IU students. A full-time resource teacher worked closely with the Dyer/Highland Park School faculty for three years, helping them develop the confidence and expertise necessary to teach mathematics using a problem-solving approach. Five teachers from the school worked for two summers writing books of problem-solving materials that they, and their colleagues, could use with their students. The university-school partnership was a very successful part of the project.

The main purpose of the *Research and Evaluation Component* was to determine the

effectiveness of each of the other components of the project. A long range goal of the entire project was to provide an improved model for training elementary teachers. By finding out which innovations were effective, the project was able to provide a tested plan for training elementary teachers to teach mathematics.

Conclusion

The *Preparing Elementary Teachers to Teach Mathematics Project* was multifaceted, aiming to improve the teaching of mathematics in the elementary schools by encouraging teachers to use a problem-solving approach. Although the major focus of the Project was the design and implementation of a new program of studies for prospective elementary teachers at Indiana University, an essential element in this endeavor was the establishment of Dyer/Highland Park Elementary School as a site for all Project-related field experiences, and the provision of frequent and ongoing inservice work for the Dyer/Highland Park faculty so that school could serve as a model site for the teaching of mathematics with a problem-solving approach.

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OVERVIEW: OTHER VOLUMES OF THE FINAL REPORT

The final report of the project is presented in five volumes:

Volume I: Overview

Volume II: Content Component

Volume III: Methods Component

Volume IV: School Component

Volume V: Research and Evaluation Component

Each of volumes II-V gives a detailed look at the work of that component. To provide information about who worked on each component and what is included in each component report, we have reproduced, on the following pages, the title page and table of contents for each of volumes II-V.

Preparing Elementary Teachers to Teach Mathematics:

A Problem-solving Approach

Final Report

National Science Foundation Grant TEI 8751478

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June 1992

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Preparing Elementary Teachers to Teach Mathematics:

A Problem-solving Approach

Final Report

National Science Foundation Grant TEI 8751478

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Volume IV: School Component

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Volume V: Research and Evaluation Component

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June 1992

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PREPARING ELEMENTARY TEACHERS TO TEACH MATHEMATICS: A PROBLEM-SOLVING APPROACH

DESCRIPTIONS OF PROJECT PRODUCTS

Descriptions of Products Related to T104

Note: The T104 Student Materials and T104 Instructor Materials below (total about 370 pages) are available in hard copy (for the cost of photocopying and optional hole punching or binding plus $2 plus postage) by contacting any *Kinkos* copy center in the nation and telling them that the books are on file in the Bloomington, Indiana *Kinkos*, 113 N. Dunn St., 812 339-3773. *Kinkos* is a nation-wide photocopy chain usually listed in the yellow pages of the phone book under "printers."

T104 Student Materials

These are the materials that the students purchase for use in the T104 course. Included in this packet are several sections: (1) Introduction, (2) Getting Started unit, (3) Numeration unit, (4) Operations unit, (5) Geometry/ Measurement unit, (6) Number Theory unit, and (7) Rational Numbers unit. Each section has a code for the numbering system. The codes are as follows: Introduction -- **I**, Getting Started unit -- **GS**, Numeration unit -- **NM**, Operations unit -- **OP**, Geometry/Measurement unit -- **G/M**, Number Theory unit -- **NT**, Rational Numbers unit -- **RN**.

The Introduction section has information about the course: purpose and organization of the notebook, information about assessment and grading, information about cooperative work, Course Schedule, Materials Schedule and Homework Schedule, Problem-Solving Tips sheet, and Notebook Grading Sheets. The Introduction pages are simply numbered in numerical order. The six units contain the pages to be used for class work and homework. Each day's work is assigned an integer. The pages are then numbered, in numerical order, following a decimal point. For example, the second day's activities in the Operations unit are identified by OP 2. The student pages are numbered OP 2.1, 2.2, etc.

The Course Schedule is a guide for the day-by-day activities of the course. An instructor may deviate from the schedule to fit the needs of a class. On the Material Schedule, those items designated with a "T" are the responsibility of the teacher. Those items designated with an "S" are materials that the students are responsible for bringing to class for that particular day. On the Homework Schedule, the assignments designated with an "A" are to be done before the next class period. Those designated with a "B" should be finished before the end of the unit. The Notebook Grading Sheets will be used by the instructor when grading the notebooks. Each student should be sure a blank one of these sheets is included with the notebook materials each time they are turned in to be graded.

T104 Instructor Materials

The instructor's manual contains a number of sections: (1) Teacher Introduction, (2) Getting Started unit teacher notes, (3) Numeration unit teacher notes, (4) Operations unit teacher notes, (5) Geometry/Measurement unit teacher notes, (6) Number Theory unit teacher notes, (7) Rational Numbers unit teacher notes, (8) Tests, and (9) Projects. Each unit has a code for the numbering system. The codes are as follows: Teacher Introduction -- **TI**, Getting Started Unit -- **GS**, Numeration Unit -- **NM**, Operations Unit -- **OP**, Geometry/Measurement Unit -- **G/M**, Number Theory Unit -- **NT**, Rational Number Unit -- **RN**, Tests -- **T**, and Projects -- **P**. For the six content units, the teacher notes are numbered with an integer in numerical order. The student pages for each activity are then numbered, in numerical order, following a decimal point. For example, the second activity in the Operations Unit would have the teachers' notes identified as OP 2 and the student pages identified as OP 2.1, OP 2.2, etc.

The Teacher Introduction section contains information about the goals and philosophy of T104, problem solving, the teacher's and students' roles in T104, cooperative learning, assessment, engaging the students in reflectiveness, teachers' notes, need for and use of a textbook, videotape viewing notes, tests, projects, text for the instructor orientation videotape, course syllabus, Information Sheet, and a Notebook Grading Matrix. Copies of the syllabus and information sheet are needed for each student on the first day of class. The notebook grading matrix is a suggested method of organizing the grading of the notebooks.

The teacher notes accompany each day's activities. These provide a list of the big ideas and mathematics content in these activities, a list of the needed materials, a suggested timetable, homework, and a discussion of the activities and problem solutions. Under **materials**, those items designated with a "T," are materials that the instructor needs to take for that day's activities. Those items designated with an "S" are the responsibility of the student. Under **timetable**, some time is devoted every day to discussion of previous homework. Obviously, this time can be used as needed. Under **homework**, the assignments designated with an "A" are to be done by the students before the next class period. Those designated with a "B" should be finished before the end of the unit.

Each day's teacher notes has the big ideas for that activity listed at the top of the page. In the **activity discussion** section these big ideas are italicized so that they will be brought to the instructor's attention and he or she can bring them out during the discussion time. When preparing for a lesson, it may be helpful for the instructor to work the activities first before reading the teacher's notes in order to get a better feel for what the students will encounter when working on the activities.

The tests section in this notebook provides (1) detailed instruction on the testing format for

T104, (2) the group and individual follow-up problems for the group parts of the tests, (3) a scoring scale for use on the group problems, (4) answers to the group and individual follow-up problems and some sample group solutions with how they were graded, (5) sample test items for the individual parts of the tests, and (6) answers to these sample test items.

The out-of-class group projects in T104 give students the opportunity to work together as a group to explore mathematics in ways other than in traditional mathematics content (and in ways other than in the T104 content). The projects section in this notebook provides (1) directions for getting the projects underway, (2) guidelines for creating new projects, (3) descriptions of the 14 current projects, and (4) directions for doing the projects.

T104 Supplemental Materials

Three videotapes have been developed by the Mathematics Education Development Center for use with the T104 course. The first tape is a 30 minute orientation tape for instructors. This tape provides some examples of activities that illustrate the role of the T104 instructor during class time. The narration and video clips concern the activities of (1) introducing an activity, (2) commenting to small groups while they work, (3) leading class discussions, and (4) wrapping up after small group work.

The second tape has two 15 minute segments that show a group of students involved in solving problems that are worked by T104 students during the first week of class. A T104 instructor selects one of the segments (either the video clip showing some past T104 students solving the "Cereal Boxes" and "Patio Tiles" problems or the clip showing some students solving the "Weird Tables" problem) to show in class. While they are watching the tape they are to note what the problem solvers do to understand the problem, develop a plan, implement the plan and evaluate the solution. These categories are provided on a Problem-Solving Observation Guide that the students fill out while watching the tape. This videotape and the follow-up discussion provide the students with the opportunity to watch other students solve problems and to see the strategies they use. Following the class discussion the students work on a reflective writing assignment discussing the problem solving they observed.

Another opportunity to see someone else solve a problem is in the second week of class when the students watch a video clip of an "expert" problem solver modelling the process of problem solving. There are three different 30 minute clips showing the solution of two different problems. The first two clips shows Jo (first clip) and Frank (second clip) solving the Valentine's Day problem. The third clip has Diana solving the Hefty Hippos problem. The T104 instructor selects one of the video clips to be shown in his or her class after the students have worked a simpler version of the modelled problem. During the modelling of the problem solving the students use a Problem-Solving Observation Guide to make notes of their observations. In the discussion

following the viewing of the tape the instructor facilitates a discussion of the problem solving modelling and brings out the ideas that (1) understanding comes in stages (sometimes a problem has to be experienced first before it is fully understood), (2) it often takes time to solve a problem, (3) it is important to be systematic, and (4) there are different ways to represent a problem.

Description of Products Related to the Methods Component

Early Field Experience Instructor's Manual

An instructor's manual was developed for use by the M201 (early field experience) instructors. The manual provides organizational features of the course, teacher notes for each weekly meeting, practical hints and suggestions and model lesson plans. (See p. 5-7 of Final Report Volume III: Methods Component for more details.)

Note: The M201 Early Field Experience Manual is available in hard copy (for the cost of photocopying and optional hole punching or binding plus $2 plus postage) by contacting any *Kinkos* copy center in the nation and telling them that the book is on file in the Bloomington, Indiana *Kinkos*, 113 N. Dunn St., 812 339-3773. *Kinkos* is a nation-wide photocopy chain usually listed in the yellow pages of the phone book under "printers."

Model Lesson Plans and Videos

Four model lesson plan series were developed for M201 (early field experience). Each series is composed of three lessons on a specific topic and has an accompanying videotape. The three lessons are for primary (K - 2), intermediate (3 - 4), and upper elementary (5 -6). See the list below. For more details see pp. 7-9 of Final Report Volume III: Methods Component.)

Graphing Series		Geometry Series	
K-2	Bar Graphing	K-1	Shape Recognition
3-4	Coordinate Grid	2-4	Line Symmetry
5-6	Frequency Distribution	5-6	Three-Dimensional Shape Recognition
Number Theory Series		**Rational Number Series**	
K-1	Odd and Even Numbers	K-2	Introduction to Rational Numbers
2-4	Prime and Composite	3-4	Rational Numbers Using Region Models
5-6	Figurative Numbers	5-6	Rational Numbers Using a Relational Perspective

Problem Databank

The computer databank consists of 474 mathematics problems: 109 primary problems, 204 intermediate problems, and 161 advanced problems, which can be searched, sorted, and printed out according to a wide variety of characteristics. See pp. 19-26 of Final Report Volume III: Methods Component for a detailed description of the databank. Note: it is essential to have Filemaker II software to use this databank of problems.

Description of Products Related to the School Component

Problem Solving Books for Classroom Use

Note: The books below are available in hard copy (for the cost of photocopying and optional hole punching or binding plus $2 plus postage) by contacting any *Kinkos* copy center in the nation and telling them that the books are on file in the Bloomington, Indiana *Kinkos*, 113 N. Dunn St., 812 339-3773. *Kinkos* is a nation-wide photocopy chain usually listed in the yellow pages of the phone book under "printers."

A Problem a Day for Primary People (approx. 364 pages) is a book of translation and process problems which can supplement any primary level elementary text book. The book consists of three sections: 150 problems for first grade, 150 problems for second, and 150 problems for third grade. Besides the problems, the book also discusses specific questions often asked by teachers such as "Why should I teach problem solving?" "What is my role as a teacher?" and "How do I evaluate problem solving?" Each section contains sample teaching questions, lessons wrap-ups, and problem variations. The problems in this book encourage students to use a variety of solution strategies and help them develop understanding of mathematics concepts.

A Logical Mystery Tour (approx. 166 pages) is a book of logic problems for students in grades 1 through 6. The book presents three types of logic problems: "Who am I" (48 logical elimination problems), "Line-Up" (36 sequencing problems), and "Matrix" (30 logical elimination problems suitable for solution by drawing a matrix). The problems within each section are organized from the least to the most difficult, and include teachers' pages with ideas for facilitating classroom discussion and guiding students through the problems. The introduction to this book also addresses common concerns of teachers and suggestions for evaluating student learning.

Projects for Real-World Problem Solvers (approx. 40 pages) is a collection of mathematical project problems which can supplement a regular mathematics program in grades 1

through 6. Each of the 14 projects is a "real-life" problem which is open-ended to allow the students to decide on the direction they should take and the strategies that should be used to solve the problem. These projects are usually assigned to be worked by groups of students over a period of time. The book contains introductory materials on teaching actions, grouping students, and helping students who are having difficulty.

A Packet of Problems to Ponder (approx. 138 pages) is a book of 66 process problems for the intermediate grades. The first fifteen problems are presented with a teacher page which gives suggestions for possible strategies, discussions questions, hints, and variations of a problem. To aid in instruction, much of the book is organized by the most common strategy used to solve the problems. The final problems are provided for additional work and are organized by difficulty rather than solution strategy.

Videotapes

Title: *Teaching Fractions Using Cuisinaire Rods*
Code #: E1
Topic: Teaching Fractions with Cuisenaire Rods
Grade: 6
Teacher: Jacqueline Gorman

Title: *Teaching Problem Solving: The Making Flowers and Making Sandwiches Problems*
Code #: E2
Topic: Process Problems
Grade: 1 and 2
Teacher: Bette Calkins and Lisa Bays

Title: *Teaching Fractions Using Pattern Blocks.*
Code #: E3
Topic: Teaching Fractions with Manipulatives
Grade: 3
Teacher: Barb Burnett

Title: *Problem Solving Using Number Tiles*
Code #: E4
Topic: Problem Solving with Manipulatives
Grade: 4
Teacher: Margie Simmerman

Title: *Using Patterns to Find the Number of Squares*
Code #: E5
Topic: Process Problems
Grade: 4
Teacher: Jacqueline Gorman

Title: *A Geometric Investigation: How Many Lines are Determined by "X" Points*
Code #: E6
Topic: Teaching Geometry Using a Problem-Solving Approach

Grade: 6
Teacher: Jacqueline Gorman

Title: *Preparing Elementary Teachers to Teach Mathematics: A Problem-Solving Approach*
Code #: P1
Topic: Overview of PETTM project
Grade: Teacher Education
Teacher: Varies

Title: *Building Toothpick Bridges*
Code #: P2
Topic: Project Problems
Grade 6
Teacher: Tammy Miller

Title: *The Dyer Mathematics Fair*
Code #: P3
Topic: Project Problems
Grade: Varies
Teacher: Various PSTs

Title: *Teaching Problem Solving: The Tables Problem*
Topic: Process Problems
Grade: 3
Teacher: Jacqueline Gorman

Title: *Teaching Problem Solving: The Squirrel in the Tree Problem*
Topic: Process Problems
Grade: 3
Teacher: Jacqueline Gorman

Title: *Teaching Fractions Using Fraction Strips*
Topic: Teaching Fractions with Manipulatives
Grade: 5
Teacher: Mamie Merrifield